Mechelecív

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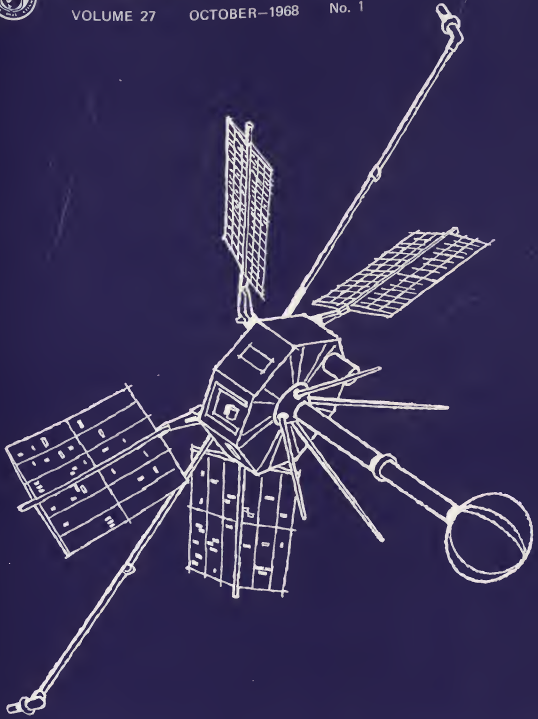

THE GEORGE WASHINGTON UNIVERSITY

OCTOBER 1968

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Goddard controlled communication satellite.

FRONTISPIECE

The Red Baron flies again. Contributed by Dean Liebowitz.

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MECHELECIV

INTENT

THE MECHELECIV magazine of George Washington University is a semi-technical magazine intended to provide a medium of communication between the school of Engineering and Applied Sciences and the academic world. It provides an opportunity for students to experience the field of journalism, and establishes a continuity within the school by reflecting the interests and ideals of the student body. The magazine also serves to inform the students of advances in the engineering field in an attempt to keep their education as current as possible.

The Mecheleciv staff chooses material for the magazine from a wide variety of sources to keep the interest of everyone exposed to it. Most contributors to the magazine are students, since their interests most closely reflect those of the student body. These contributions range from news about activities on campus to formal articles. The other source of material within the school is the faculty. The professors of the SEAS contribute regularly to the six issues of Mecheleciv each year, and act as advisors to the students who make up the staff. They are also cooperative in bringing the authors of research papers and theses to the attention of the Mecheleciv staff since these papers provide excellent material for the magazine.

Another important source of information is the many research companies who contribute willingly of their time and materials to the magazine. Corporate publicity departments provide ample material for our technical news section as well as providing the information for many of the feature articles printed in the magazine.

Other sources, as yet only partially exploited, are other schools of the university, such as the School of Journalism and the art school, student leaders and administration personnel, and the alumni of the Engineering School.

The Mecheleciv has a circulation as varied as the sources from which it draws its information. The magazine is mailed to the home addresses of all incoming freshmen, and these addresses will remain on the mailing list so that all engineering undergraduates will eventually receive the magazine as will all future alumni. The magazine is circulated throughout the School of Engineering and the University. It also reaches all its advertisers and contributors, all member schools of the Engineering College Magazine Association, and many professional men and organizations. This varied circulation necessitates a broad appeal in the magazine which is achieved by choosing topics accordingly.

The Mecheleciv staff does not dictate the type or style of articles printed in the magazine; however, it maintains strict control over the quality of material published by suggesting improvements in the articles and by using selective editing. In this way, the staff hopes to produce a magazine which will enlighten the student body and its colleagues to the merits of the George Washington School of Engineering while providing a superior journal of engineering for all.

CAMPUS NEWS

A NEW GRADUATE ENGINEERING PROGRAM

This past summer, THE GEORGE WASHINGTON UNIVERSITY in cooperation with THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION'S LANGLEY RESEARCH CENTER announced a full resident graduate program leading to the degree of Master of Science in the fields of Aeronautics, Applied Mechanics, Astronautics, Mechanical Engineering, Electrical and Computer Engineering.

Programs or study are designed to meet individual interests and needs with provision for collateral study in related areas. The graduate programs are arranged so that the student carrying two courses a semester may complete his course work for the masters degree in two years. This program contains the necessary flexibility to accommodate the beginning graduate student as well as those with graduate transfer credits.

Students may be permitted to transfer a maximum of 6 semester hours of approved graduate course credit from other accredited institutions.

The courses will be taught by NASA scientists and engineers and the faculty of the GEORGE WASHINGTON UNIVERSITY'S SCHOOL OF ENGINEERING AND APPLIED SCIENCE. NASA-Langley's extensive scientific and engineering facilities and equipment will be utilized whenever feasible.

The graduate programs are open to qualified NASA employees and area residents. Courses may also be taken by nondegree students, with the approval of the instructor.

ENGINEER'S COUNCIL

COUNCIL POSITIONS OPEN

George Stellar, president of the Engineers Council, announced three positions open on the Council. These include two Freshman Representatives and one Sophomore Representative. Those interested in these positions should obtain petition information from any member of the Engineers Council or Room 100 Tompkins Hall. At the end of October an election will be held to fill these positions.

DR. EFTIS RECEIVES GRANT

Dr. John Eftis

Dr. John Eftis, associate professor of Engineering and Applied Science, Department of Engineering Mechanics, School of Engineering and Applied Science, The George Washington University, has received a $1000 grant from the American Society for Testing and Materials (ASTM).

He will use the grant in his continuing research on the alkali metals which has developed theoretical expression, based on quantum considerations, for (1) strain-energy, (2) non-linear stress-deformation relations, (3) a necessary condition for hyperelastic response, (4) second-order isothermal elastic coefficients, and (5) the components of the acoustical tensor.

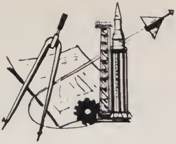
ASTM annually presents grants to engineering and science schools to promote pure and applied research in materials or the properties of materials. Each school selects its respective recipient of the grant. The funds are placed at the disposal of the faculty member who is directing the selected research project and he may use them for the purchase of equipment or materials, or for the support of faculty or student personnel engaged on the project.

ASTM is an international, nonprofit, technical, scientific, and educational society concerned with research and standards for products and for materials of every type. It is the largest developer of nationally used voluntary standards – both industrial and consumer – in the United States.

Dr. Eftis is a native of New York City. He received his B.C.E. degree in 1952 from The City College of New York, his M.S.C.E. degree in 1958 from Columbia University, and his D.Sc. degree in 1967 from The George Washington University.

Dr. Eftis joined the faculty of George Washington University in 1962 as assistant professor of Engineering and Applied Science. At the same time he was a researcher in the Mechanics Branch of the Naval Research Laboratory and a consultant for several firms.

From 1964-67 he was a graduate student at the University and in 1967 assumed his present position as associate professor.



TECH NEWS

Edited by David R. Armstrong, E.E., 70

METEORITES YIELD RARE FORM OF DIAMOND

Diamonds, of a structure never before found in nature, have been identified in some meteorites by scientists at General Electric's Research and Development Center.

Though scientists have known for decades that certain meteorites contain diamonds, these were believed to be of the ordinary "cubic" structure – the diamond form used for gem stones and industrial abrasives.

The substance identified by G.E. scientists, known as "hexagonal" diamond because of its crystalline structure, was originally synthesized from graphite at the Research and Development Center, but never before found in nature. However, the conditions under which this new substance was created in the laboratory suggested strongly that it might occur in meteorite samples.

Scientists at G.E.'s R & D Centers have now discovered that hexagonal diamond is associated with ordinary diamond in meteorites – a discovery that casts new light upon the formation of diamonds in meteorites. Previously, some scientists suspected that meteorite diamonds were formed by intense heat and pressure deep inside celestial bodies at least the size of the moon. However, other scientists theorize that the meteorites never belonged to such large "parent" bodies and that the fragments underwent a violent impact with the earth or with other objects deep in space.

Using careful X-ray studies, the Center scientists have shown that the meteorite diamonds were formed directly from graphite by intense impact shock, rather than from heat and pressure within a large "parent." Identification of hexagonal diamond in meteorite samples was made by Drs. F. P. Bundy, R. E. Hanneman, and H. M. Strong.

In G.E.'s laboratory process for making hexagonal diamond, a well crystallized sample of graphite is subjected to pressure as high as three million pounds per square inch and heated to temperatures above 2,400°F, the "setting" temperature of hexagonal diamond. The sample is then allowed to cool before the pressure is released, and a mixture of hexagonal and cubic diamond is formed.

G. E. scientists study models of hexagonal and cubic diamond.

WESTINGHOUSE SCIENTIST 'IRONS' DEFECTS OUT OF MATERIALS

A Westinghouse scientist has discovered a way to "iron" certain materials with heat and pressure to change their properties. He indicated that a new class of materials may eventually result.

Dr. Abraham Taylor, a physicist at the Westinghouse Research Laboratories, devised a method to press out the holes left by "misplaced" atoms in what scientists call defect-laden alloys and components. Dr. Taylor uses pressures ranging from half a million to a million and a half pounds per square inch. By contrast, pressure a mile deep in the ocean – enough to crush a submarine – is less than 2,500 pounds per square inch.

The "ironing" is done at red-hot to white-hot temperatures between 1,500 and 3,000 degrees Fahrenheit, and is

followed by rapid cooling. This shapes up the molecular structure of the material so that the atoms are neatly arranged in crystal form. The effect of the treatment is like that of a sponge pressed flat, except that the change is permanent unless the material is again heated several hundred degrees.

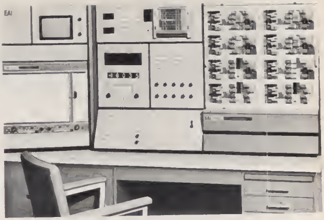
The process applies to materials such as titanium monoxide, which are normally full of many sub-microscopic holes where an atom should be but isn't – sometimes as many as 25 per cent of the atoms of each element in the material are out of place. All or only some of the holes may be eliminated, depending on degree of property changes sought. Dr. Taylor reported an experiment where squeezing the holes out of titanium monoxide more than tripled its superconducting critical temperature. This is the temperature where materials suddenly lose all resistance to electric current, a phenomenon important to modern technology.

Dr. Taylor stated that it is well known that these holes can exert a tremendous influence on other physical properties such as electrical resistance, elasticity, aging, working characteristics and magnetic qualities. He also stated that the elimination or reduction of the holes might result in a new class of materials. Westinghouse is continuing to investigate the potentials.

EAI 580 DESK-TOP ANALOG/HYBRID COMPUTING SYSTEM

Electronic Associates, Inc., manufacturer of scientific computing systems, announced the EAI 580 Analog/Hybrid which is a completely new solid-state ten volt, desk-top

Model of atomic structure of titanium monoxide after being "ironed out" by new process.



EAI 580 analog/hybrid computing system equipment.

computer with a capacity of 80 computing amplifiers and eight comparator amplifiers. It is an advanced analog computer that is easy to understand and operate, in addition to providing all the capabilities needed for integration into a hybrid computing system.

The 580 was born out of the growing need for high performance analog computation, as well as the requirement for a hybrid oriented desk-top computer. It combines the low cost of a desk-top computer with the outstanding characteristics and sophistication of more costly medium and large scale analog/hybrid computers. It also offers the features a digital computer user needs so that he may take advantage of the additional capability afforded by both hybrid and modern analog computation.

The following features of the EAI 580 reflect the advanced analog and hybrid computing capabilities of the system.

- Mode selection, time selection and computing component control are accomplished by logic signals. All interator trays in the computer can be controlled individually, or in groups from the analog mode control, digital logic program or by a digital computer. This important feature permits the efficient use of iterative analog and hybrid techniques for the solution of boundary value problems and partial differential equations.
- Electronic Mode Control allows higher problem solution speeds, and more flexible control of integrators from logic devices by incorporating solid-state switches in place of relays.
- Outstanding dynamic and static characteristics of the analog computing elements permits high speed repetitive and interative, as well as real time operation, with maximum accuracy.
- The self-contained logic expansion of general purpose logic gates, flip-flop registers, counters and digitally controlled analog switches allow decision making, event initiation, data reduction, timing and control to be accomplished directly in the EAI 580. When operating with a digital

CONTINUED PAGE 10

computer the logic can be either synchronized with an internal clock system or slaved to an external signal from the digital computer.

• The EAI 580 is the first desk-top analog computer with servo set potentiometers. Up to 70 servo pots can be read and set up using either the keyboard addressing system of the analog console or the digital computer. In pure analog problems they allow faster potentiometer setup. In hybrid problems these automatically adjustable potentiometers may be set to coefficients calculated by the digital computer. They may also be used directly to vary parameters during a simulation by means of a manual proportional controller.

• The computing capability of the 580 can be conveniently expanded in the field without additional console wiring. The computer console is completely pre-wired to accept a variety of plug-in components. Power supplies provided with the basic computer are capable of operating a fully expanded console. In addition, extensive trunking and slaving facilities permit the combined operation of several 580's as one large system.

• The EAI 580 simplifies and insures full integration into a hybrid computing system by providing for direct addition of a built-in hybrid control interface.

The EAI 580 is the ideal machine for use in government, industrial and educational facilities, providing the user with an analog/hybrid computing capability to analyze the myriad of increasingly complex problems occurring in virtually every scientific discipline. Scientists and engineers involved in the study of dynamic physical systems will find that the computer gives them the ability to solve an extensive variety of problems. At the same time, simplicity of operation offers the beginner the opportunity to become familiar with the superior performance and sophistication demanded by and essential to seasoned users of analog and hybrid computers, says Electronic Associates, Inc.

WESTINGHOUSE INVESTIGATING ELECTRON BEAM ROCK CUTTER

Dr. B. W. Schumacher, a scientist for Westinghouse Research Laboratories, has been experimenting with an electron beam rock cutter that could carve tunnels out of mountains with its powerful beam of energy.

As described by Dr. Schumacher, the instrument shoots out a narrow beam of electrons a few inches long that looks like a white-hot needle. Dr. Schumaher stated that it melts through many kinds of rock like a hot knife through wax. When fully developed, the device could be used for tunnels, trenches for pipes, quarries and mines, where it should prove to be faster than other methods. It works just as well under water as above. It even cuts through iron rods in reinforced concrete, and might be particularly useful when city streets have to be dug up.

The energy density of an electron beam – the punch that it packs – can exceed that of all other known continuous duty energy sources such as flame jets and laser beams. The electron beam rock cutter will be more mobile than mechanical cutters and drills, because it has no 'kick' requiring elaborate bracing and support. And it will avoid the jarring and weakening effects that blasting produces in surrounding areas. Dr. Schumacher also stated that the device can make clean melt-cuts for carving out sections of rock or, in certain kinds of rock, can produce stresses that spall the surface (cause it to shatter and flake off). Flame cutters such as the oxygen torch can only spall rock because of heat spread, but the rock cutter aims electrons like bullets that penetrate to maximum depth almost instantly. Dr. Schumacher stated that indications are that the electron beam rock cutter will be economically competitive with other methods.

Electron beam rock cutter slices through granite rock.

The major problem in developing the device was that an electron beam must be formed in a high vacuum, yet there has to be a hole in the assembly to let the beam out. This was solved by arranging a series of continuously pumped vacuum chambers in the instrument, with apertures along the path of the beam, and by having a steady stream of gas blow out of the last aperture to prevent dirt and debris from being sucked in.

Electron beams produce X-rays, but at the voltage level of the rock cutter they are readily contained by shielding, Dr. Schumacher said.

The electron beam rock cutter is a 300 pound unit consisting of a power supply and an electron gun. It is operated by remote control from a console.

DEAN HAROLD LIEBOWITZ

MORE THAN OUR SHARE

The years at college should be wondrous years filled with the excitement of learning, of obtaining general and specialized knowledge, to understand man in relationship to himself and his society and the world in which he lives. It is time for the student to achieve a sense of wonder of the past, a working knowledge of the present, and an inkling of the limitless possibilities of the future. The days and nights should be filled with this love of learning and a desire and motivation to devote oneself to the rigorous discipline necessary to prepare for the future.

Too often, however, these are years of plodding and drudgery. The faculty dutifully exposes the student to what is considered requisite and the student dutifully absorbs, usually not very deeply, to the point where he is able to recall sufficient of the information to achieve passing grades. This is a most unfortunate situation.

Fortunately, one man can make the difference between dullness and wonder, between doing the bare minimum and burning the midnight oil. These gifted teachers are among our rarest resources and the School of Engineering and Applied Science is indeed lucky in its faculty.

With the gifted teacher every bit of knowledge is almost an adventure. Every fact, idea, or concept is not an end in itself, but the consequence of some previous work or thought and is leading, implicitly or explicitly, somewhere else. The information may be related to several other disciplines. It may suggest ideas in the humanities and social sciences. The gifted teacher will excite his students by making all these relationships and implications clear. He overwhelms the student, confuses and forces him to think and work by himself to the point where the student is sufficiently conditioned to undertake independent study. The gifted teacher achieves immortality through his students.

The gifted teacher is first of all a master in his field. He stands at the outer limits of the state of the art, and is fully aware of the limitations of his knowledge. He is usually impatient to push the limits as far as he can. He is able to excite, motivate, inspire, direct, and guide his students. Along with the transmission of knowledge he will also in some mysterious manner imbue the student with a love of learning and condition him to the point where no effort is considered too great.

Thus, the keystone of any educational institution is its faculty. While it is desirable to have a physical plant that is attractive, spacious, and conducive to concentrated effort; it is more desirable to have a first rate faculty, dedicated to their disciplines and devoted to their students by being consistently responsive to their changing needs.

In addition to the various explosions that the world is experiencing in information and population, there is also here in the United States an extensive increase in the college population that has not yet reached the point of explosion but is not far from it.

The increase in student population has had an immediate effect upon all schools and colleges. There is a need for buildings, facilities, and equipment, and even more important, teachers. While it is possible to accelerate the construction of buildings and facilities, it is not quite that simple to obtain first rate teachers.

There have been many studies made on how best to overcome the teacher shortage. Many ideas have been advanced, including: programmed learning utilizing teaching machines and computers; closed circuit TV; taping lectures on video tape and using them in outlying areas at a later date. There are many more worthwhile ideas that have been advanced and utilized, many of them showing much promise. There is no point or purpose served in the sterile argument as to whether the teacher can be replaced by a teaching machine. Teaching machines serve a very useful purpose and are best used to augment and enhance learning at every level.

The complexity of the teaching process can be gleaned from a dictionary definition of the term "teach": "to cause to know a subject; to cause to know how; to accustom to some action or attitude; to make to know the disagreeable consequences of some action; to guide the studies of; to impart the knowledge of; to instruct by precept, example, or experience; to seek to make known and accepted."

In addition to these various shades of meaning, the dictionary also offers the following synonyms: "Instruct; education; train; discipline; and school. Teach applies to any manner of imparting information or skill so that others may learn; Instruct suggests methodical or formal teaching; Educate implies attempting to bring out latent capabilities; Train stresses instruction and drill with a specific end in view; Discipline implies subordinating to a master for the sake of controlling; School implies training or disciplining especially in what is hard to master or to bear."

The insights afforded by the dictionary definition of the complexity of the teaching process also makes clear the reasons why teaching machines cannot replace the teacher.

One aspect not covered by the dictionary definition of "teach" is the inspiration or motivation of the student by the first rate teacher. Using the conventional course materials, the first rate teacher can present the information in a manner which involves the student to the point where he must go beyond the limits of the course as taught; where he must find out for himself, as quickly as possible; where he must relate his information with all other knowledge that he has.

The School of Engineering and Applied Science is particularly fortunate in having more than its share of first rate faculty members, who have distinguished themselves by the range of their experience in teaching and directing research. Many educators believe that at the higher levels of education, the teaching experience can only be meaningful when it is tied to research.

As examples of first rate faculty, biographical descriptions are included only for the department chairmen and a few of the members who have recently joined the staff. This limitation, because of space considerations, is unfortunate because nearly all the faculty members would merit serious consideration on anyone's list of first rate teachers. However, a later edition of MECHELECIV will include an introduction to all the faculty of this Engineering School.

Dr. Galip M. Arkilic, professor and chairman of the department of engineering mechanics has served for more than 10 years on the faculty of this School. Dr. Arkilic did his undergraduate work at Cornell university; obtained his masters degree in mechanics at the Illinois Institute of Technology; and completed his doctorate in theoretical and applied mechanics at Northwestern University. He taught for several years at Pennsylvania State University and has considerable full-time industrial and consulting experience. Dr. Arkilic has published many papers, including: "Studies in the Theory of a Dislocated Continuum;" "A Formulation of Displacement Equations from Quantum Mechanical Energy Considerations;" and "On Continuous Distributions of Dislocations."

Dr. Louis de Pian, professor and chairman of the department of electrical engineering, has served for more than 11 years on the faculty of this School. He did his undergraduate work at the University of Athens and obtained his advanced degrees, M.S. and Ph.D., in electrical engineering at Carnegie-Mellon Institute. Dr. de Pian taught at Carnegie-Mellon for several years and has extensive experience as a consultant. He is the author of "Linear Active Network Theory," published by Prentice-Hall, and has also written many papers, including: "Analysis of Multi-Terminal Networks," "On the Stability and Dynamic Behavior of Cascaded Thermoelectric Devices," and "Scattering Matrix Parameters for Thermal Transducers."

Dr. Herbert E. Smith, professor and chairman of the department of engineering administration, has served on the faculty at this School for more than 9 years. Dr. Smith did his undergraduate work at the College of the City of New York and obtained his advanced degrees, M.S. and Ph.D., at New York University. He taught for several years at the

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OPERATIONS RESEARCH
ITS AIMS AND METHODS

By R. William Rae

OPERATIONS Research was identified as a separate activity during World War II, when groups of scientists were conducting research on military operations. The purpose of their studies was basically to assist commanders in making the best use of men and equipment to accomplish a desired objective. Spurred by the early successes in the military field, operations research grew in stature and sophistication, and its methods were quiskly adopted by industry. Operations research is interested in the same problems as management, whether military or industrial, and seeks to provide executives with an analytical tool to assist them in evaluating alternative courses of action in decision making.

This is not intended to give you a short course in operations research – commonly called OR – but rather to discuss the philosophy of OR and to touch on some of the methods used. Although OR is "research," it differs from the classical concept of laboratory research in the physical sciences. The laboratory research worker generally can collect his data by conducting experiments over which he has almost complete control and which he can repeat as often as he wishes. The OR scientist, on the other hand, is often concerned with the study of a dynamic system over which he has little control.

The following remarks are slanted exclusively toward military OR, since that is where my experience lies, although this is but one of the many areas of application of OR methods.

Our aim in studying the operation of a system is to seek ways of improving it. Perhaps the operation, whatever it is, can be carried out with fewer men, at less cost, or in a shorter time.

For our purpose, a system is any group of objects – men and machines, for example – that are related in some way, to perform a specific operation or mission. The army as a whole is a system; and on a smaller scale, a man with a rifle is a system.

Since military OR is concerned with improving the effectiveness of the army, why not study the operation of the army as a whole? For example, if a question arose as to how a portion of the Army budget should be spent to obtain the maximum increase in effectiveness, OR would be useful tool to examine whether it would be of most value to expend the funds on weapons, training, communications equipment, etc., in the light of the Army's missions.

If, on the other hand, the problem is to improve the effectiveness of an infantry soldier on a patrol mission (does he need a more accurate weapon, a higher rate of fire, more food, or less?) it would obviously be impractical to study this in the context of the operation of the Army as a whole. Thus the size of system for study should be selected so that it includes all factors relevant to the problem but not so large that we are swamped with vast amounts of extraneous data.

One might say that it is always desirable to have more weapons, bigger weapons, more lethal weapons, and that no study should be necessary to show that the Army's capabilities would be improved it it were equipped with the most modern and most powerful weapons. However, this is shallow thinking, since it ignores the mission or the operation. For example, for operations in Southeast Asia, an OR study might show that it would be more effective to equip the Army with 105 mm howitzers, which could be

moved about fairly readily, than with more powerful but heavier 155 mm guns, which might bog down in the mud a large percentage of the time.

The question is sometimes asked: To what extent does operations research differ from systems engineering? I won't try to define these terms, because it is possible, by choosing your words appropriately, to indicate either that the two disciplines are entirely different or that they are essentially similar. Perhaps I can illustrate my own views on how they differ by an example.

Suppose that a unit commander in Southeast Asia has been involved in operations where he has tried to move across country but found that his vehicles kept getting stuck in the rice fields. Since the term "mobility" seems to be fashionable these days, the Commander's report to Headquarters would probably be an agonized plea for more mobility.

If this problem is given to an engineer, the chances are that his approach will be to measure soil bearing strengths in the area, determine bank gradients of streams, examine the merits of wheels versus tracks, and eventually come up with a design for a vehicle that performs better than the previous ones.

On the other hand, if the problem is assigned to an OR scientist, his first approach should be to study the operation in which the vehicle is to be used. What is the purpose for which the unit has to move from A to B? What is the time element involved? Why is a vehicle needed? Could the operation be performed equally well (or better) on foot, on bicycles, using elephants, pogo sticks, or helicopters? It it appears that a vehicle is needed, then the problem should be turned over to the engineers to design a vehicle with the necessary performance capabilities.

By this example I don't mean to imply that the work of the OR scientist is any more important than that of the engineer, but that the two activities are complementary. Both are important and necessary. The OR study, however, should generally precede the engineering study to ensure that effort isn't expended to produce a better mousetrap if what is needed is a flyswatter.

An important aspect of an OR scientists's job is to define the problem, since the person asking a question does not always recognize what his real problem is. Once you have defined the problem clearly, you're usually well on the way to finding a solution.

Let me illustrate this with an experience from World War II, when the tank battles were raging across the deserts of North Africa. For a time, the British tank gunners were having considerable success against the Germans. Then suddenly the situation changed: The Germans began knocking out British tanks, whereas the British guns seemed to have become ineffective against the Germans.

Since British intelligence had learned that the Germans had introduced a new tank gun sight, the British gunners blamed their lack of success on an inferior sight and clamored for research to develop a better one. A British research group was able to show that the sight was about as good as could be developed and that the trouble must be elsewhere. Further observations disclosed that the British shells were actually hitting the German tanks but broke up on impact with the frontal armor plate, which had been greatly strengthened. As soon as it was pointed out that the problem was in the design of the shell and not in the sight, it was a relatively simple technical matter to provide a solution.

Now that you have some idea of the OR approach to a problem, you may be interested in some of the methods used in our studies. If you talk at any length to an OR scientist, you will frequently hear him refer to models — physical models and mathematical models. The reason we are interested in models is that it is difficult to study a system even as large and complex as a company in actual operations, let alone something as large as an army.

A physical model — such as a model train or model airplane — is a miniature representation of the real thing which is easily handled. Although these models do not usually contain all the detail of the original, they simulate their full-scale counterparts.

Thus if we were to try to study the forces involved in an actual battle, we might build a physical model of the system. We could take a map of the appropriate area, deploy toy soldiers or other types of pieces on the map to represent the actual forces, move these pieces about according to a battle plan, and observe the results. This is essentially what is done in war gaming.

What we would prefer to do — but this is not always practical — is to build a mathematical model of the system under study so that we can do our minipulations with a pencil and paper instead of physically moving pieces about a table. A mathematical model is nothing more than a series

Mr. Rae is presently a member of the Technical Staff of the Research Analysis Corporation in McLean, Virginia. He received his B.A. in Mathematics and Physics with honors at the University of Toronto in 1938. His M.A. degree in Physics was earned in 1939, with his thesis entitled "Methods of Quantitative and Qualitative Spectroscopic Analysis."

He worked for the Meteorological Service of Canada from 1940 to 1953. From 1953 to 1955, Mr. Rae was Defense Scientific Service Officer, Defense Research Board, Canada. Mr. Rae served as a member of the Canadian Army Operational Research Establishment from 1955 through 1963.

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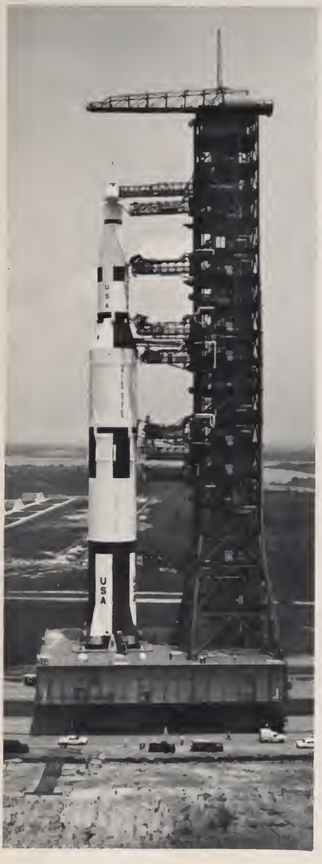

GODDARD SPACE FLIGHT CENTER

By Christopher A Kouts

WITH the increasing numbers of orbiting satellites and space probes it is evident to all of us that man is well on his way toward the great adventure of exploring the universe. In the past the great leaps forward have come about through individual motivations. However in this world of today progress is being made through the concerted effort of huge laboratories and centers sponsored heavily by the government. It has become a race against time in the research and development area pitting one nation against another. In essence it is a technical race for survival.

It has been said that the greatest gift that we, as a nation, ever received in modern times was Sputnik. When Sputnik went up the whole of the engineering, scientific, and educational fraternities woke up. Assessing the situation, this nation found itself short of manpower in science and technology, basic research, applied science and research and development plants. Federal obligations in this area had to be vastly increased. One of the beneficial results was the creation of the National Aeronautics and Space Administration. NASA is now spearheading the systematic and scientific search for space knowledge.

One of NASA's principle centers is the Goddard Space Flight Center which must carry the brunt of space developments in unmanned satellites. Specifically, it is responsible for the development of unmanned orbiting satellites in the interests of basic and applied science,

sounding rocket experiments, and NASA's world-wide network of tracking stations serving manned and unmanned scientific space missions. In recent months, this center has received considerable play from news media because of the explosive increase in unmanned atmospheric measurement probes, the shift in emphasis on lunar exploration within NASA from manned to unmanned highly automated vehicles, and the criticisms received from the General Accounting Office for the poor past accounting practices in managing NASA's world-wide tracking network. A firm understanding of Goddard's role within NASA is therefore definitely in order at this time.

Established on May 1, 1959, the Goddard Space Flight Center is located in Greenbelt, Maryland, Ten miles northeast of Washington, D.C. The staff at Goaddard now approaches 3,800, of which nearly half are associated within the fields of physics, astronomy, geodetics, mathematics, geology, engineering and astrophysics.

The areas of study within Goddard can be classified into three separate divisions.

The first division of study could be called the study of our origin star, the sun. Since the beginning of time, man has always wondered about that blazing inferno which burns his skin during the summer and gives him light the year round. Now with the advent of the satellite and the space probe, which can rid scientists of the translucent atmosphere which cuts out a high percentage of the sun's varied radiations, technicians at Goddard have been able to observe details and effects of sunspots and solar flares which are a basic cause of many phenomena experienced here on earth.

Interplanetary space is the second area in which researching scientists are deeply interested. Within this region of our solar system probes and satellities have been sent to measure radiation, magnetic fields, electron concentration and radio wave propagation.

Besides studying solar and interplanetary space data technicans at Goddard are also investigating the near-earth region called the magnetosphere. This is the region in which the magnetic field of the earth exerts a major influence. At the equator the magnetosphere extends up some six earth radii or 24,000 miles; at the magnetic ples this shield becomes much thinner so that solar effects such as the aurora occur at much lower altitudes.

Goddard also manages NASA's Meteorological Satellite Experimentation Program including a most important developmental assist to the TIROS operational system managed by the Environmental Sciences Service Administration. NIMBUS, the polar orbiting experimental spacecraft, and all ATS (Applications Technology Satellites) geosynchronous spacecraft have been well publicized and

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City College, Renssalaer Polytechnic Institute, and the University of Maryland. Dr. Smith has considerable full time industrial and consulting experience. His principal publications include "Bibliographical Essay on Engineering Management," and "Cases in Engineering Management."

The department chairmen represent an excellent blend of rigorous preparation, practical industrial experience, and successful teaching. The faculty has been augmented by the following members, each of whom has already distinguished himself in his field. There is no doubt but that the School, the students, and the faculty will be the better for their presence.

Dr. Alfred M. Freudenthal, professor of civil engineering and technical director of the Institute for the Study of Fatigue and Reliability, did his undergraduate work at the Institute of Technology in Prague, obtained his M.Sc. at Prague University, and his D.Sc. at the Institute of Technology. He has more than 25 years of teaching experience at the Hebrew University in Haifa, the University of Illinois, and Columbia University. He has extensive industrial and consulting experience both here and abroad. Dr. Freudenthal has achieved an international reputation for his research in inelastic behavior and failure of materials; mathematical theories of inelasticity; fatigue and creep; and structural reliability. He has written more than 130 papers in technical and scientific journals and has written and edited about 8 books. He has received medals from the American Society of Civil Engineers and the Swedish Aeronautical Society.

Dr. S. W. Yuan, professor of aeronautical engineering, did his undergraduate work at the University of Michigan and Stanford University. He completed his advanced degrees, M.S. and Ph.D., at the California Institute of Technology. He has been teaching since 1945 at the Polytechnic Institute of Brooklyn, Universite Laval, and University of Texas. He has extensive full time industrial experience and is internationally known for his research in the fields of helicopter aerodynamics, structures, stability and vibrations. He has authored two books, "Cooling by Protective Fluid Film," Princeton University Press, and "Foundations of Fluid Mechanics," Prentice Hall. He has written numerous papers for sicnetific and technical journals.

Dr. Guenther Hintze, research professor, comes to the School after 23 years at the White Sands Missile Range where he was director of the analysis and computation directorate, national range operations. He did his undergraduate work and obtained his masters degree at the Technical College in Breslau, Germany, and was awarded an Honorary Doctor's Degree by New Mexico State University. Dr. Hintze was a part time professorial lecturer at the University of Texas, El Paso. He has written many scientific articles and recently published his first book: "Fundamentals of Digital Machine Computing." Dr. Hintze has extensive industrial experience and was with Dr. Werner von Braun's group that spearheaded the Army's missile program. Dr. Hintze developed the flight simulation laboratory facilities for performing nondestructive evaluation of missile systems by means of mathematical analyses and flight simulation techniques.

Dr. Robert S. Ledley, research professor in the fields of computer science and technology and medical engineering, did his undergraduate and masters work in mathematics at Columbia University. He received a degree in dentistry (D.D.S.) from the New York University College of Dentistry. Starting in 1956, Dr. Ledley taught for four years at the School of Engineering and Applied Science, where he organized and taught the first graduate and undergraduate courses in digital computers. He has extensive industrial and consulting experience in computer utilization with organizations such as the National Bureau of Standards, the Johns Hopkins University, the National Institutes of Health, National Science Foundation, Air Force, and National Library of Medicine. Dr. Ledley is President of the National Biomedical Research Foundation, a private organization devoted to the use and application of computers in biological, medical, and dental research. Dr. Ledley has authored 10 books and has written almost 100 articles for technical and scientific journals.

In the 16th century, Montaigne, who was concerned, much as we are today, with education and educators, very perceptively describes the art and practice of the first rate teacher:

"Tis the custom of pedagogues to be eternally thundering in their pupils's ears, as they were pouring into a funnel, whilst the business of the pupil is only to repeat what others have said: now I would have a tutor to correct this error, and, that at the very first, he should according to the capacity he has to deal with, put it to the test, permitting his pupil himself to taste things, and of himself to discern and choose them, sometimes opening the way to him, and sometimes leaving him to open it for himself.

"Let the master not only examine him about the bare words of his lesson, but about the sense and substance of them, and let him judge of the profit he has made, not by the testimony of his memory, but by that of his life. Let him make him put what he has learned into a hundred several forms, and accommodate it to so many several subjects, to see if he yet rightly comprehends its, and has made it his own."

Great teachers and great writers have much in common, and we all owe them a great debt of gratitude for the excitement they create in making us want to learn.

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DR. H. E. SMITH

DR. G. M. ARKILIC

DR. L. de PIAN

DR. A. M. FREUDENTHAL

DR. S. W. YUAN

DR. G. HINTZE

DR. R. S. LEDLEY

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of mathematical equations whose parameters are so selected that as the variables in the equations take on values corresponding to some operation of our real life counterpart, the values generated by our equation will correspond to those of the actual operation. As an illustration, perhaps the simplest system in the Army is one man with a rifle, and let us say that the specific operation of this system is the man with a rifle shooting at a target; and the result we are interested in is the number of times out of a given number of shots that the man hits the target.

In practice, we know it is unlikely that our man will hit the target every time, but that out of N shots, he may hit it k times, where k is less than N to a degree dependent on the skill of the man and the accuracy of the weapon. From elementary probability theory, we also know that as N becomes large, the ratio k/N approaches a constant value, which we might call p. In other words,

$$p = \frac{k}{N}$$

and the mathematical model of our operation may be expressed as

$$k = pN$$

Thus if N were taken as 100 shots and we had previously determined p to be equal to 1/2, the expected number of hits would be 50. You may have noticed that the value of p had to be previously determined by some means. Such a term as this "p," which is theoretically a constant, is what I previously called a parameter; and a large part of OR work is concerned with trying to determine realistic values for the various parameters that appear in the mathematical models that we may dream up. We use every means available to us – historical data from previous wars, proving ground tests, and field experiments. If none of these provides the necessary data, then we have to resort to our ultimate weapon, the use of assumptions.

You may perhaps instinctively feel that if a study leans heavily on assumptions, it is not worth much as a basis for practical decisions. This is not so, provided that each assumption is explicitly stated so that the user knows what limitations it imposes. Moreover, if at some subsequent date new information becomes available that permits us to assign a specific value to what was previously an assumption, we can often determine that effect this will have on the final result without having to do the entire study over again.

We sometimes use "parametric analysis" to forestall possible criticism over the use of assumptions. For example, let us suppose that one of the parameters in our model preferred to the distance a given type of unit could move on foot in a day over moderately rough terrain. We may know from experience that even with the most superhuman efforts it is unlikely that the troops will be able to cover more than 20 miles. We may also estimate that no matter who battle-weary the troops are, they should be able to cover five miles. Thus we would have an upper and a lower limit for the value of the parameter. We could then work the problem through for each of these values and determine the results.

The difference in the two results would provide us with a measure of the sensitivity of the problem to that particular parameter. If the difference is small, we would know that there was no need to expend much effort in trying to obtain an accurate value for that parameter; if the difference is large, we would do our utmost to try to pin down the value of the parameter as accurately as possible.

Although OR is by no means the way to solve every problem, an OR scientist should make a sincere effort to try to substitute fact for opinion in complex situations through the analysis of such facts as can be obtained. With this approach, and when done conscientiously by a capable staff, OR can be an invaluable aid in the making of decisions.

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are primarily responsible for the great increase in atmospheric measurements and the general state-of-the-art in sensor development.

In order for any venture into space, manned or unmanned, to be successful a continuous flow of information between ground stations and spacecraft must be maintained. Goddard Space Flight Center acts as the computing hub of NASA's World-wide Satellite Tracking and Data Acquisition (STANDAN) and Manned Spaceflight Centers. Fifteen tracking stations which dot the globe provide precision tracking and command and telemetry data to the communication center at Goddard. Using ultra-modern computers and the latest communication and telemetry equipment Goddard is now able to control both manned and unmanned vehicles besides handling voice communications.

Now that the painstaking task of building NASA and its centers, such as Goddard, has been mostly completed, NASA must now routinely go through the agony of preserving its entire structure. This has become a formidable task especially since the 1967 Apollo fire, Government Accounting Office criticisms of its property accounting and the advent of funding cuts necessitated by the Vietnam War. NASA as a result is busily pushing and justifying its programs centered on the peaceful applications of space development and attempting a strong follow through in its corrective actions of cost effectiveness. It appears that the wonderful pool of engineering and scientific talent at Goddard and elsewhere is under some jeopardy for possible lack of some managerial abilities that must be a necessary ingredient in any such mammoth and successful aerospace venture.

"Mark ye well engineers of G.W.U., get on with your advanced degrees in business and management." The world including NASA can well use a man with multiple technical and managerial abilities.

Pete Drobach has a knack for getting to the root of a problem.

High school students John Magish and John Ripley would be the first to agree.

They're both student members of a "big brother" program that Pete sponsors. Each week, they spend several hours of their own time helping less advanced classmates with their studies.

Pete is more than a sponsor. He's also a consultant—particularly when they're stumped by the logic of a tough "new math" problem.

But when Pete graduated from Rutgers in 1964, it wasn't these youngsters with their homework problems that brought him to General Electric. It was the chance to help people in industry solve tough technical problems. A career in technical marketing at General Electric gave him the opportunity.

Today, Pete's an application engineer in steel mill drives and automation systems. His ideas on how to apply products from many of GE's 160 separate businesses enable his customers to improve the efficiency and productivity of their plants.

Like Pete Drobach, you'll find opportunities at General Electric in R&D, design, production or marketing that match your qualifications and interests. Talk to our man when he visits your campus. Or write for career information to: General Electric Company, Room 801A, 570 Lexington Avenue, New York, N.Y. 10022.

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